Recommendations of Freshwater Quality Work Group, Coastal and Barrier Network, 25 January 2001

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The work group agreed at the outset that a major factor affecting the design of a monitoring program for any NPS water resource is the preservation goal for that resource. Managers need first to decide on the long-term goal, i.e. is the surface water body a natural feature in a natural zone where preservation includes both native ecosystem components and processes, or is the water body largely or totally the product of human manipulations, in which case the goal may be to preserve merely a physical appearance, e.g. the historic scene? Our monitoring recommendations for specific types of surface waters reflect this consideration, especially with respect to frequency of monitoring (Table 1).

The group further agreed that, although our charge is limited to nutrient loading, acidic anions, both nitrate and sulfate, can contribute to the eutrophication of freshwaters and therefore should be included in the monitoring.

Freshwater resources and management issues

This summary is based on phone conversations with, and written reports provided by, the indicated park resource management contacts.

Assateague Island National Seashore (ASIS). Contacts: Karl Zimmerman, Chris Lea, Jack Kumer
The park includes about 20 freshwater-to-brackish ponds on the barrier island. No water quality monitoring is under way; however, there have been surveys of fish and some chemical and physical characterizations. Park managers are concerned about horse trampling of native vegetation and the spread of *Phragmites* at the ponds. Because horses feed widely but concentrate at the ponds, they may also import substantial nutrients to pond water with effects on dependent species. Groundwater extraction occurs at the park but does not affect surface waters because it occurs from a deep aquifer beneath two confining layers.

Cape Cod National Seashore (CACO) Contacts: J. Portnoy
CACO includes 20 freshwater kettle ponds, several hundred seasonally flooded wetlands in both dune slacks and depressions in glacial outwash, and about 500 acres of coastal freshwater wetlands (tidally restricted) including about 10 km of tidal freshwater streams. Water quality concerns include phosphorus loading from increasing shoreline

development and pond use, atmospheric deposition of sulfuric and nitric acid, and potential groundwater pollution and extraction.

The Park was selected as the prototype site for the development of an inventory and monitoring program for Atlantic and Gulf coastal parks in the early 1990's and protocols are being developed for estuarine water quality, coastal geomorphic change, hydrology, birds, small mammals, freshwater fish, amphibians, and reptiles. Experience from this Cape Cod prototype program should expedite planning and implementation of monitoring region-wide.

CACO has operated an NADP site continuously since December 1981. CACO characterized the chemistry of its vernal wetlands in the mid-1980s.
The pH and alkalinity of kettle ponds and tidal freshwater streams have been monitored since 1984. A detailed kettle pond water quality monitoring protocol has been implemented with periodic technical review since 1993.

<u>Fire Island National Seashore</u> (FIIS) Contact: Jim Ebert
The park consists of the barrier island and includes clusters of private dwellings ("communities") with on-site wasterwater disposal. Freshwater, semi-permanent shallow ponds occur in dune swales, some adjacent to the communities and potentially affected by wastewater leachate. Most ponds are seasonally flooded and none are much deeper than 2 ft. No water quality data are available for these ponds.

<u>Gateway National Recreation Area</u> (GATE) Contact: Bob Cook
Sandy Point (NJ) has both permanent (~2 m deep) and temporary ponds between dune ridges, with no local threats to water quality. Most other streams and "ponds" within the Park's New York City units are artificial, highly modified and receive lots of runoff. The 45-acre and 100-acre impoundments over old salt marsh at Jamaica Bay Wildlife Refuge are generally fresh (salinity<2 ppt) with heavy bird use, cyanobacterial blooms and oxygen depletions. The 300-acre Great Kills site on Staten Island has shallow freshwater marsh and streams that receive most water from urban runoff.

<u>Sagamore Hill National Historic Site</u> (SAHI) Contact: Norm Farris
The Park has several small ponds and wetlands that could be damaged by runoff from adjacent development, i.e parking lots and landscaped areas. NPS recently completed a "Level I" water quality inventory at SAHI including two ponds and two emergent wetlands.

<u>Colonial National Historical Park</u> (COLO) Contact: Charles Rafkind
COLO has 32 miles of shoreline along the Chesapeake, 55 miles of perennial and intermittent streams fed by springs and seeps, 2400 acres of wetlands including 700 acres of forested wetlands. Upgradient agriculture and residential and commercial development are probable sources of nutrients to park wetlands. Development is increasing rapidly adjacent to certain park units. Naval activities (Yorktown Naval Weapons Station) have caused contamination, likely including nutrients, at 16 sites, all upstream from Colonial Parkway or adjacent to the Yorktown unit of the Park.

All streams have had benthic studies. USGS-WRD has conducted geohydrologic work and located seeps and springs. The park does not conduct routine water quality monitoring, but there are data from well sites in York County, where N and P species were at or below detection limits. Also, urban and agriculture impacts to shallow groundwater and surface waters were assessed over four quarters in 1993, and found local groundwater contamination by NO_3 and NH_4, but not PO_4, at several sites near developed areas. Stream NO_3 was primarily contributed by groundwater; and groundwater and surface water N species were positively correlated. PO_4 was low even in samples high in DIN, expected given the aerobic groundwater environment.

<u>George Washington's Birthplace</u> (GEWA). Contact: Rijk Morawe
This historic site includes a ¾-acre pond, 4-5 ft deep, and a freshwater marsh, both down-gradient of extensive agriculture which is just outside the park. These farms have used fertilizer of unknown quantity and quality; they are currently planning on applying sewage sludge to their fields. Besides adjacent agriculture, park staff are concerned about atmospheric deposition from nearby industrial and urban sources and recent Phragmites invasion of brackish marshes which park staff think may be caused by increased nutrients.

<u>Thomas Stone NHS</u> (THST). Contact: Rijk Morawe
THST includes several springs, seeps and first-order streams down-gradient of agricultural fields that are maintained as part of the historic scene. The principal stream (albeit intermittent), Hoghole Run, skirts the western park boundary and probably intercepts agricultural effluent from fields just outside the park. Low-density housing with on-site wasterwater systems is also upgradient of the park.

Background information

<u>Regional hydrology</u>
Discharge to surface waters in coastal parks may be dominated by ground water because of typically sandy soils. If not already available from other agencies or academia, each park should have sufficient water table, soils and surficial geologic mapping to assess whether nutrients could be transported to park freshwaters via groundwater flow. This question is primarily important in parks with sandy, permeable soils where groundwater, rather than surface flow, is the principal source of water to park ponds, streams and wetlands.

Streams and watersheds entering the part should be defined. Impervious surfaces, which can dramatically influence flow and nutrient transport during storms, should be mapped.

<u>Monitoring “stressors”</u>
In addition to the response (“indicator”) variables described below, <u>stressors</u> common to all park units, and those entities already monitoring them, should be inventoried as a basis for park staff to design their own monitoring program without omission of important

variables and without duplication. These include adjacent land use, atmospheric deposition , altered stage and hydroperiod, and both human and wildlife (including feral animal) use of park waters. It is likely that state or regional agencies are already collecting data available to park units, or state programs may be expandable with NPS contributions of staff time or funds to more directly address park management concerns. For example, state and county planning agencies regularly acquire aerial photography and monitor land use change. Also, local atmospheric deposition data, if not collected at a park, are usually available from NADP-NTN sites run by nearby government agencies or universities.

Indicator variables

A Baseline Set of water quality variables to assess nutrient loading includes **total P, PO_4, NH_4, NO_3, organic N, conductance, pH, alkalinity, turbidity or transparency, chlorophyll α, color and/or dissolved organic carbon (DOC), dissolved oxygen, SO_4, Cl, Ca, Mg, K, Na, and Fe**. Primary production in most freshwaters is P-limited, although it can become N-limited if P supply greatly exceeds the requirements of primary producers. Total P includes all phosphorus species in the water column and is a better measure of P availability than dissolved inorganic P because the latter is assimilated so quickly as to be often undetectable. Dissolved inorganic nitrogen species, NH_4 and NO_3, can fuel eutrophication in freshwater systems receiving very high P loads and indicate the degree of nitrogen saturation, an increasing problem in the Northeast with the atmospheric deposition of nitrogen oxides. Conductance, pH and alkalinity are basic to understanding each freshwater system's ionic strength, acid balance and chemical stability in the face of atmospheric pollutants or changes in the watershed. Both SO_4 and Fe are important to P cycling within lakes and ponds. The other major ions are needed to interpret pollutant sources or possible water quality effects.

Site selection

It is recommended that park resource managers and cooperating experts conduct a site specific review of resources and threats and then choose sites for baseline and periodic monitoring based on 1) long-term management objectives for the water body and 2) level of concern for nutrient loading over both long and short terms. Ideally, baseline conditions should be established for as many water bodies as possible. However, where a park includes many similar water bodies subject to similar eutrophication threats, a <u>sample</u> of streams, ponds or wetlands should be selected that represent the range of depth, flow, trophic status, vegetation, and sensitivity to adjacent threats. See also Implementation, below.

General guidelines by resource type (see Table 1)

Intermittent streams should be mapped and characterized physically and vegetatively, using remote sensing data (mainly aerial photographs) as much as possible. A stream survey, similar to a pond or coastal shoreline survey, should be conducted to find any point discharges (i.e. pipes) and map bank erosion, especially where adjacent lands are developed. An initial Baseline Set of water quality constituents and indicators should be measured during high flow to characterize water quality including flow, DOC, TP, TN, NO_3, NH_4, dissolved oxygen, turbidity, and qualitative macro-invertebrate samples (e.g. sweep net).

Perennial stream variables include all of those for intermittent streams, but conducted during both high and base flows. In addition, stream-flow gauging stations should be established at a minimum with staff gauges that can be conveniently and regularly read by park staff, cooperators and volunteers. Because aquatic macro-invertebrates are useful indicators of water quality and integrate temporal change, artificial substrates should be deployed and sampled during periods that bracket the water chemistry sampling. In addition, quantitative data should be consistently collected during the low-flow periods, e.g. mid-summer, that are most stressful to aquatic fauna.

[Because of the major biogeochemical disturbance in coastal wetlands that have been historically diked and freshened, the original brackish-to-saline tidal creeks that currently drain these wetlands are now freshwater and can be both acidified and hypoxic. If tidal restrictions are documented or suspected at specific coastal sites, more intensive sampling and research may be required for appropriate method selection and accurate interpretation of monitoring data. This also applies to park wetlands in coastal flood plains.]

Shallow ponds are defined as being less than two meters deep with no consistent summer stratification of the water column, unlike deeper ponds. Examples are the perennially flooded dune slack ponds of ASIS, CACO, and GATE (Sandy Hook). Besides the Baseline Set of variables, emergent and shoreline aquatic macrophytes should be mapped on a ten-year cycle in natural zones, and more frequently (e.g. five years) where nutrient pollution from septic leachate or runoff is nearby. Staff gauges should be established and read at least whenever water quality is sampled. Dissolved oxygen should be monitored over at least one diel cycle at mid-depth during mid-summer to assess organic loading and possible hypoxia, especially at night. Because oxygen stress can be characterized over a short time period (e.g. one 24-h day-night cycle), data loggers need not be deployed for long periods and can be moved to sample many ponds within a season. Phytoplankton sampling and identification should be undertaken when there is a history of severe algal blooms.

Vernal ponds are seasonally flooded kettle depressions within the glacial outwash landscape of CACO. So long as adjacent lands remain undisturbed the Baseline Set of variables, originally employed in the mid-1980s, is generally adequate for future monitoring, at a recommended ten-year interval. An important addition would be the characterization of diel dissolved oxygen fluctuations, as for the above shallow ponds, especially in late spring when increasing temperatures increase oxygen demand. Pond stage measurement, qualitative sweeps for macro-invertebrates and at least qualitative vegetation mapping should also be conducted in late spring (May).

Deep ponds are 10-20 m in depth and seasonally stratified; they are restricted to CACO in this Network. A water quality monitoring program, developed by NPS and USGS staff with external peer review, has been operational since 1993. The work group recommends the addition of DOC and the identification of dominant phytoplankton groups (e.g. to family taxonomic level) especially during algae blooms.

Wetlands range from herbaceous marshes in dune slacks to forested swamps to artificially restricted coastal marshes (see perennial streams,above). These should be characterized initially with the Baseline Set of variables, dissolved oxygen over a 24-hr period, vegetation mapping and DOC every 5-10 years. Because of the potential for historic hydrologic alterations in the coastal zone (e.g. salt marsh diking, filling, drainage), it is important to characterize sediment quality as both an indicator of past hydrologic change and as a factor that can radically affect surface and receiving water quality. Suggested sediment variables include organic content, bulk density, pH, Eh, total C, total N and, in porewater, major anions and cations including Fe. In general, these need be measured only once, with subsequent monitoring dependent on what is found and the potential for hydrologic or land-use changes.

Implementation

The above recommendations are intended to be general guidelines that need to be refined into specific monitoring designs for each park. This refinement could be accomplished by park staff, university cooperators and consultants using the following steps.

As a first step at each park unit, staff and/or cooperators should undertake a survey of on-going monitoring by state agencies, universities or other groups. These entities are potential partners, usually with similar data needs and land management goals. Next should be a review of historic data to refine water quality issues, to identify point and non-point sources and to better choose monitoring sites that are representative and sensitive to additional nutrient loading. This survey will also produce a review of the methods and quality assurance/quality control being used by regional monitoring groups. The Vital Sign program proposes to adopt common, or at least comparable, methods for similar environments throughout the eight network parks; surveyed non-NPS methods may or may not be compatible with this goal.

The next step would comprise sampling the representative sites chosen above and assessing results with respect to proposed indicators of nutrient loading. To assess temporal variability and to ultimately develop a program that can detect long-term trends, we recommend more frequent sampling initially. This may involve monthly sampling of eutrophication indicators like Secchi depth and chlorophyll α on an annual basis for five and perhaps ten years. These early monitoring results should be reviewed by a team of experts (Advisory Group) who then can recommend an appropriate long-term monitoring interval and, over the longer term, technically review the protocols, methods, results and interpretations of NPS staff and cooperators performing the actual monitoring.

A complete review of each program (i.e. methods, data, analyses) should be performed by the Advisory Group every five (10?) years, with more frequent assessments in the event of major land-use changes in or near a park unit.

It is imperative that sampling and the quality assurance and quality control of analytical methods be clearly documented, consistent and comparable among all network sites. Data reporting, storage methods and platforms should also be consistent to allow comparison across the network and compatibility with STORET or other NPS data bases recommended by the Data Management Work Group.

Parks should also consider involving volunteers for simple tasks such as: collecting water samples, reading staff gauges, assisting with land use surveys, conducting shoreline and stream surveys for point sources of pollution etc. The use of volunteers, however, requires a large time commitment for orientation, training and frequent checking of quality control.

Nearby parks should plan on sharing equipment, e.g. dissolved oxygen meters, among themselves and/or with cooperators.

Table 1. Matrix of freshwater resources, nutrient threats and recommended indicator variables to be monitored for the Vital Signs program. Sampling frequencies are only tentative and will depend upon the results of more frequent initial sampling to determine natural variability.

			Indicator variables	
Park	**Freshwater resources**	**Nutrient threats to water quality**[1]	Baseline Set	Repeat when?
ASIS	Dune slack ponds (~20)	Horse trampling and excreta	√	10 years
CACO	Kettle ponds (20)	Septic leachate, bank erosion, swimmers		Annual including depth profiles
	Dune slack semi-permanent ponds (100s)	Unknown	√	10 years
	Vernal ponds (~60)	Unknown		10 years
	Diked salt marshes (~200 ha)	Hydrologic disturbance	√	5 years
	Tidal fresh streams (10 km)	Septic & landfill leachate, Hydrologic disturbance	√	Annual
COLO	Intermittent streams (50 km)	Upgradient agriculture, commercial and residential development; Yorktown Navy Station	√	5 years
	Perennial streams (38 km)		√	Annual
	Swamps (300 ha)		√	5-10 years
	Springs and seeps		√	5-10 years
FIIS	Semi-permanent dune slack ponds	Septic leachate via groundwater; deer excreta	√	5-10 years
GATE	Dune slack ponds	Unknown	√	10 years
	Impoundments (59 ha)	Bird excreta	√	During algal blooms
	Urban streams	Street runoff; erosion	√	Annual
	Urban wetlands		√	10 years
GEWA	Dug pond (~0.3 ha)	Adjacent agriculture	√	5-10 years
	Emergent marsh		√	10 years
SAHI	Small ponds and wetlands (several)	Runoff from parking lots and landscaping	√[2]	10 years
THST	Intermittent streams	Adjacent agriculture, septic leachate	√	Annual
	Springs and seeps		√	?

[1]All freshwater resources are subject to atmospheric nitrate and sulfate deposition.
[2]Included in earlier Level I survey.